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16. Abstract

The teleobservation and surveillance of the surface of the earth by satellite cannot limit itself solely to the geographical confines of the state or states which have authorized the activity, or who are participating in the experiments. In regard to risks of international disputes arising from space prospecting of terrestrial resources, even if carried out with the consent of certain states, and taking account of the contradictory interests of the economic and military establishments implied in this type of activity, it is to be hoped that the judicial subcommittee of the U.N. will not delay in initiating appropriate international procedures.

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STUDY OF TERRESTRIAL RESOURCES BY SPACE OBJECTS

AND INTERNATIONAL LAW

Marco G. Marcoff

The capacity for multidimensional observation by space objects opens broad perspectives for study both of the natural conditions of the earth's environment and of the mineral, biological, and economic resources of the earth's surface and subsurface, as well as the expanse of the ocean.[1] /343*

Study of the terrestrial medium, which is the principal objective of space prospecting, is of interest both to industrialized states and to those which are still underdeveloped, or which are at present just beginning their economic development as independent countries.[2]

Although experimental and exploratory work in this area has already begun, there are still no international regulations on the use of space technology for scientific and economic teleobservation, except for the general standards of conventional territorial rights. /344

The possibility of satellite teleobservation in the areas of crop identification (condition of vegetation, species cultivated, degree of maturity, etc.), terrestrial and aquatic biological resources, and mineral deposits has already been compellingly demonstrated by the combined aerospace experiment carried out in 1969, using the HB-57 F airplane and the Apollo 9 space capsule.[3] Mosaics of multispectral photographs[4] taken at an orbital altitude in the upper and lower atmosphere were pieced together to show a vast expanse of the Salton Sea area in California.[5] Similar photographs, obtained by analogous methods of aerospace observation, have been taken of the Caspian Sea region in the U.S.S.R.

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*Numbers in the margin indicate pagination in the foreign text.

On July 23, 1972, the first satellite in the American ERTS program (Earth Resources Technology Satellites) was launched from Vandenberg Air Force Base north of Los Angeles. The ERTS-A is designed to take systematic photographs of the earth's surface in various bands of the invisible and infrared spectra, and for this purpose it is equipped with three very large-aperture television cameras (4,500 lines) operating in diverse bands of the spectrum, and also with a radiometer with multispectral scanning on four channels. Data is stored in two very rapid magnetic recorders. The satellite is also equipped with a data collection system designed to gather information on hydrology, agriculture, forestry, meteorology, pollution detection and geology.[6] Complete surveillance of the earth's surface is accomplished every 18 days from an altitude of about 920 km. Launching of the second satellite in this series, the ERTS-B, is projected for 1973.

In order to create the legal conditions necessary for colla- /345 boration in this area, and particularly to use the data obtained by satellite prospecting for their economic development, Brazil and Mexico made contractual agreements with NASA at the end of 1968 through their national space research organizations.[7] Their experiments, however (Electra Mission MSC P-# A), showed that teleobservation activities by ultra-sensitive scanners cannot possibly be limited to the exact territory of the state which has given its consent, but that such activities inevitably touch on the economic, political and strategic concerns of neighboring countries. The range of the detectors extends beyond the boundaries of the country being observed, since the data registration takes in an area at least 185.2 km wide and inevitably covers a large part of the adjacent territory.[8]

Using teleobservation from space to turn the earth's resources to account has been the subject of several important studies by the Economic and Social Council of the U.N. in 1970.[9] The special study prepared on this subject by the Secretariat of the United Nations[10] emphasizes that the simultaneous use of aircraft and space objects is currently the main factor in obtaining increased ground resolution[10a] and consequently more useful data. However, the same official study also pointed out that from now until 1975, the resolving power for detectors installed in satellites orbiting at an altitude of about 800 km will be from 18 to 61 m. Around 1980, the precision of data collection will have increased so much that it will be quite possible to distinguish, from an orbital altitude, ground-level objects with a with a size of only 3 to 15 m.[11]

In spite of assertions such as these, regulation of the study of terrestrial resources by space objects has been of little interest to the specialized body of the United Nations, the Juridical Subcommittee of the CUPEEA. The subcommittee has not only kept itself aloof from the studies undertaken by the Economic Council, but also remains separate from other developments initi- /346 ated by the Scientific and Technical Subcommittee of the CUPEEA since 1970.[12] In May 1972, argument was actually made before the Juridical Subcommittee that it was still too soon to develop any international body of laws to regulate the teleobservation of the earth's resources by satellites, since the techniques of observation were in the experimental stages and the methods and range of these activities were still imprecise.[13]

Nevertheless, it is possible to see real danger for Third-World countries in this so-called "experimental" stage of operations. Serious problems of sovereignty connected with economic[14] or strategic[15] reconnaissance present themselves even now on an international scale. The fact that 32 countries and 300 scientists of various nationalities are taking part in the ERTS-A program does not offer any assurance that the legitimate interest of other countries will be duly safeguarded. Terrestrial surveillance by space objects has a global range; bilateral or multilateral accords reached on a political or regional scale are not likely to guarantee the universality necessary to assure that a global program of space teleobservation of terrestrial resources conforms to international law.

Following the recommendations of the General Assembly of the U.N. (Resolutions 2600 [XXIV] and 2733 [XXV]) the states represented on the Scientific and Technical Subcommittee decided to create and convene a Study Group on the Teleobservation of the Earth by Satellite.[16]

At its 1998th plenary session, on November 29, 1971, noting that this study group had held its first organizational meeting, /347 the General Assembly urged the CUPEEA and the Technical and Scientific Subcommittee "to make every effort to see that the Study Group shortly begins its activities per se" (Res. 2778 - XXI, p. 4).

This task was undertaken from May 3-9, 1972, when the Study Group held its "preparatory" session. Unfortunately, the Group intended to have its work depend entirely on the "preliminary" results of the ERTS-A satellite. Thus, becoming enmired in rather vague considerations, it preferred to postpone its basic work for a later date.[16] It was undoubtedly this delay, as well as the total absence of conclusive opinion from the Scientific and Technical Subcommittee on the basic problems related to the use of so-called terrestrial resource satellites, which permitted the Juridical Subcommittee to adjourn its study of the juridical aspects of space teleobservation, even though this question was on the agenda for its eleventh session in 1972[17], and notwithstanding the presence of an important "Draft Agreement on Satellite Activities of Teleobservation of the Earth's Resources," presented by the Republic of Argentina in 1970.[18]

The teleobservation and surveillance of the terrestrial medium by satellites cannot possibly be limited to the geographical areas of the state or states authorizing these activities, or of those participating in the experiments. Taking into account the risk of international disputes which may arise from prospecting the earth's resources from space, and also with a consciousness of the contradictory economic and military interests implied by this kind of activity, there is reason to hope that the Juridical Subcommittee of the United Nations will not delay its duties any further and that it will no longer leave this problem exclusively in the care of the Scientific and Technical Subcommittee or the Economic and Social Council. In actuality, very precise technical details on the teleobservation capabilities of satellites were known and publicized long before the launching of the ERTS-A.[19]

The legitimate desire to fulfill scientific and economic expectations on the study of the earth's resources by space objects cannot justify the pursuit of activities having both scientific and strategic aspects, without taking into consideration the grave /348
economic consequences of teleobservation for states bordering on those directly involved.

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1. Cf. Premier Rapport [First Report] of expert on applications of space technology, U.N. Doc. A/8020, Suppl. 20 (1970), App. 2, pp. 21 ff.; Le role des satellites de la Terre dans l'etude de l'environnement [The Role of the Earth's Satellites in the Study of the Environment], U.N. Doc. A/AC 105/C 1/VIII/GRP 2; J. Barboza, "Los satelites equipados con sensores remotos y los recursos naturales," Proceedings XIIIth Coll. (Constance, 1970), pp. 337-352; E. Brooks, "New Developments of Earth Satellite Law," ibid., pp. 337-352; V. S. Vereshchetin, "Legal Regulation of Investigation of Natural Environment from Outer Space," Proceedings XIVth Coll. (Brussels, 1971), pp. 110-114; A. A. Cocca, "Legal Problems Relating to the Evaluation, Conservation and Development of Earth Resources by Means of Space Objects," ibid., pp. 99-109 and our study The International Aspects of Remote Sensing Satellite Activities, Il Diritto A Aereo, 1972, No. 42. For more details, see Chap. 12 of our Traite de Droit international public de l'espace [Treatise on Public International Law of Space], Editions Universitaires, Fribourg-Geneva-Paris-New York, 1973.

2. A study group on the possibility of using space objects for the management of food resources and other related areas has been instituted by the Food and Agriculture Organization. See Premier Rapport, op. cit. supra, n. 1, pp. 22-23.

3. For a thorough disclosure of these results, see J. M. Noyer, Director of the NASA Program of Terrestrial Observation, in 1971 NASA Authorization, H. R. 15695, v. II, pp. 1061 ff., with diagrams and photographs illustrating the various detection capacities of the red, infrared, near infrared, and green bands. Cf. also the photographs on vegetation in Arizona, ibid., p. 1068 and on geological structure in Indiana, ibid., p. 1070.

4. The multispectral receivers revealed: crops (identification) and geological formations in the red and infrared band; vegetation, identification of waterways, etc., in the near infrared band. The inventory of terrestrial resources also includes the observation of variable phenomena and phenomena depending on weather conditions, the quantitative and qualitative evaluation of crops, etc. Cf. the performance of the 24-channel radiometer (Bendix Corp.) in automatic spectral analysis, op. cit., n. 2, p. 1134.

5. NASA SR photographs 70-323, ibid., p. 1063 (1970).

6. V.P.O. Jeannet, "Le satellite ERTS," La Recherche Spatiale, v. 11, No. 3 (May-June 1972), pp. 9-10; cf. W. E. Scull, The Earth Resources Technology Satellites ERTS-A and B, NASA edition (1971), with 12 diagrams and figures; L. Jaffe and R. A. Summers, "The Earth Resources Survey Program Jells," Aeronautics and Astronautics (April 1971), pp. 24-40.

7. See Accord of Rio de Janeiro of 1-18 and 10-10-1968, TIAS 6569, pp. 6066-6071 and Tlatelolco Accord, Mexico, of 12-20-1968 on cooperative research by teleobservation for terrestrial observation, TIAS 6613, pp. 1-8; cf. the table of cooperative ERTS programs in International Cooperation in Outer Space: A Symposium, ed. by Mrs. Eilene Galloway, 92 Cong., 1st Sess., Senate Doc. 92-57, Washington, 1971, p. 47. Cf. also the accord on the study of the environment by aerial and spatial observation reached by NASA and the U.S.S.R. Academy of Sciences on 1-21-1971, op. cit., pp. 667-668, and Recommendations by the Joint Working Groups (Aug. 2-6, 1971), II, pp. 9 ff. (unpublished NASA document).

8. See Memorandum Change 28NHB 8030 1A, Opportunities for Participation in Space Flight Investigations, NASA Doc. of July 2, 1970.

9. U.N. Doc. E/4779 of Feb. 4, 1970; cf. Part 2 of Res. E/1480 (XLVIII).

10. Les Satellites pour l'etude des ressources naturelles: leur role eventuel dans le developpement economique et social [Satellites for study of natural resources: their eventual role in economic and social development]. U.N. Doc. E/4779, Appendix, pp. 5-46.

10a. For the exact meaning of the term "ground resolution," see the table and the official explanation of the CUPEEA, given as an appendix.

11. See the precise data from documentation available to the United Nations (U.N. Doc. A/AC 105/C 1/GRP 2 of 3-2-1970, App. II, 1 and 2, infra, p. 348).

12. Cf. Eilene Galloway, The Role of the United Nations in Earth Resources Satellites, study presented at the Regional Conference of the American Society of International Law (Santa Clara University School of Law, Feb. 4-5, 1972), pp. 1-20, at p. 2.

13. See, for example, the comments of Mr. Reis (U.S.) at the 188th meeting of the Juridical Subcommittee, May 3, 1972, U.N. Doc. A/AC 105/C a/SR 188 (prov.), pp. 12-15, at p. 15, with the significant declaration that if there were to be an examination of the problem of terrestrial teleobservation by space objects, "the U.S., for its part, would certainly not be in any position to participate advantageously."

14. See, on this subject, Res. 1803 (XVII) of the General Assembly on permanent sovereignty over natural resources and wealth, Annuaire francais de droit international, 1962, pp. 516 ff. On the dangers of economic espionage, see V. S. Vershchetin, op. cit. supra, n. 1, p. 111.

15. On the perfected strategic reconnaissance capabilities of the "Big Bird" and on "Project 647," see Peter M. Ronner's recent "Weltraum-Spionage auf neuen Wegen," Die Weltwoche, Zurich, 38 (Sept. 30, 1972), p. 55.

16. See Rapport du sous-comite scientifique et technique sur les travaux de sa 8e session [Report of the Scientific and Technical Subcommittee on the Activities of its Eighth Session]. U.N. Doc. A/AC 105/C 1/L 42 of July 13, 1971, par. 15, p. 5. On the necessity of linking the activities of the new Work Group with those of the Juridical Subcommittee, see the comments of the academician Blagonravov (U.S.S.R.), U. N. Doc. A/AC 105/C 1/SR 81 of July 7, 1971, p. 3. Cf. Resume de la session preparatoire du Groupe de travail de la teledetection terrestre par satellites [Resume of the preparatory session of the Work Group on Terrestrial Teleobservation by Satellites], held in May 1972, U. N. Doc. A/AC 105/102 of May 15, 1972, App. 1, pp. 1-3.

17. See U.N. Doc. A/AC 105/101 of May 11, 1972, par. 5, pp. 2 and 10, p. 4. Cf. Rapport du Sous-comite scientifique et technique sur les travaux de sa 9e session [Report of the Scientific and Technical Subcommittee on the Activities of its Ninth Session], U. N. Doc. A/AC 105/102 of May 15, 1972, App. 1, par. 15 ff., p. 3.

18. U. N. Doc. A/AC 105/C 2/L 73 of June 23, 1970. Cf. the reaffirmation of the Argentine proposal before the Juridical Subcommittee in 1972, U. N. Doc. A/AC 105/C 2/SR 190 (prov.), pp. 2-3 (comments of Mr. Delpech at the meeting of May 4, 1972).

19. Cf., for example, the bibliography on the technical aspects of terrestrial observation by means of space objects, Remote Sensing of Earth Resources. A Literature Survey with Indexes, NASA Edition SP-7036 (Sept. 1970) and COPUOS, Selective Bibliography on Remote Sensing, Spec. Doc. 71-40095, Aug. 18, 1970.

APPENDIX

Approximate Size of Surface Area Covered Photographically and Ground Resolution* as a Function of Altitude and the Focal Length of the Lenses**

Altitude (in ft)	Focal Length (mm)	Linear Dimension of Surface Area (in ft)	Ground Resolution G (in ft)
10,000	50	10,000	2.00
	150	3,334	0.67
40,000	50	40,000	8.00
	150	13,334	2.07
500,000 (**)	50	500,000	100.00
	150	166,667	33.34 (*)
2,500,000 (**)	50	2,500,000	500.00
	150	833,334	166.67

Independently of the value of G, accurate data cannot be obtained unless there is adequate contrast between the objects on the ground. This depends on the specific spectral characteristics of the objects, as well as the filters and types of film used (infrared Ektachrome, Panchrome, etc., for various filter films).

-- Ground resolution (G) is the smallest linear dimension of an object situated on the ground which can be discerned in a photograph taken from an airplane or a satellite. The G factor depends on: a) the altitude A from which the photograph is taken and b) the focal length (f) of the photographic lens. The area of ground covered by each exposure varies according to these two factors, so that there is a choice of obtaining either a greater surface area covered by each exposure, or a greater amount of visible ground detail, by modifying (a) and (b).

The following formulas apply:

$D = FA/f$ (1)
$S = A/f$ (2)
$G = S/300\,R$ (3) where:

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*For 50 mm film whose resolution R = 100.

**Ordinary altitudes for satellites (about 150 km, about 750 km).

F is the size of the photographic film used.

D is the linear dimension of the surface area visible in each exposure.

A is the altitude of the aircraft or space object.

S is a metrical value determined by equation (2).

f is the focal length of the lens.

G is the ground resolution.

and R is the resolution of the film (in lines/mm).

For a good quality film, R is = 100.